Thermophilic post-digestion to enhance biogas recovery and digestate quality from on-farm agro-residues

SEMPRE-BIO

Shruti Katti[1], Çağrı Akyol[1]*, Jean-Baptiste Joos[2], Erik Meers[1]

[1] *Laboratory for Bioresource Recovery (Re-Source), Department of Green Chemistry and Technology, Ghent University, Coupure Links 653, 9000 Ghent, Belgium*

[2] *Innolab CVBA, Marechalstraat 70, 8020 Oostkamp, Belgium*

**cagri.akyol@ugent.be*

The Flemish case study of SEMPRE-BIO

The Flemish case study (CS3) is located on a dairy farm in Adinkerke, Belgium, and aims to transform on-farm agro-residues into bio-LNG and liquid CO_2 on a smaller scale. The digestion process takes place in two parallel reactors each with a volume of 2.700 m^3 (the latter being a thermophilic post-digester), which are fed with on-farm manure and other residues. The biogas upgrading unit is a cryogenic process that enables the separation of CO_2 from biogas. A part of the excess digestate, together with the liquid CO_2, are then used to grow microalgae and purple bacteria as alternative protein sources for animal feed.

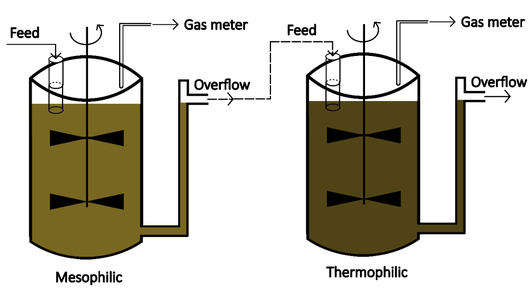
Objectives

Before proceeding with the farm-scale implementation, preliminary anaerobic digestion (AD) experiments were conducted at bench- and pilot-scale to assess the feasibility and to identify potential challenges. The experiments were designed to mimic the same operating and environmental conditions as the CS3 scenario, ensuring accurate and reliable results for future applications.

Experimental setup

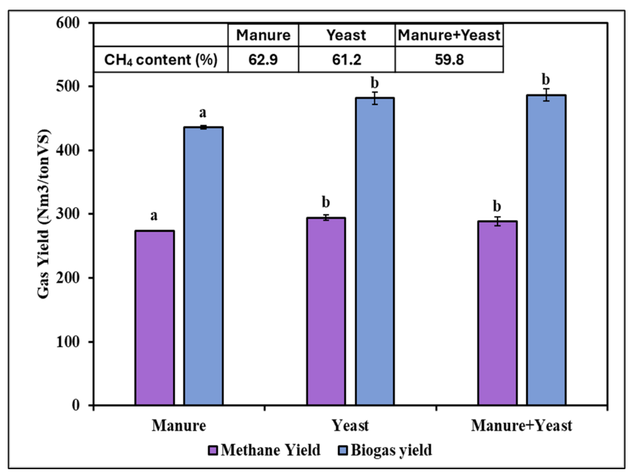
Initially, biochemical methane potential (BMP) tests were conducted under thermophilic conditions (52 °C) to determine the methane yields of cow manure and yeast concentrate (as a potential and available co-substrate on the farm). Then, semi-continuous pilot-scale AD tests were run in two 72L continuous stirred-tank reactors (one mesophilic and one thermophilic – the latter being a post-digester as the hygienization step) with a hydraulic retention time (HRT) of 28 days.

The reactors were first operated with cow manure for 4 HRTs and then with cow manure + yeast concentrate (5:1 v:v) for additional 2 HRTs to monitor the biogas production at steady-state conditions.



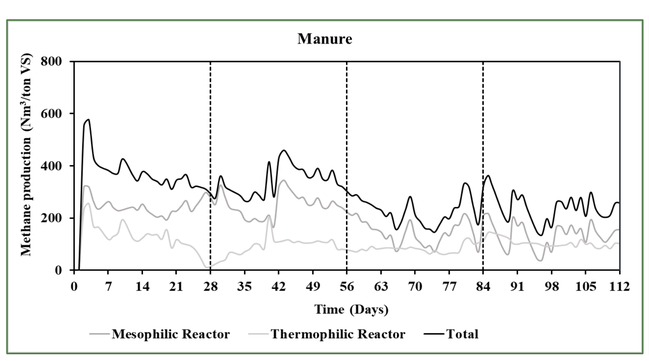
Results and discussion

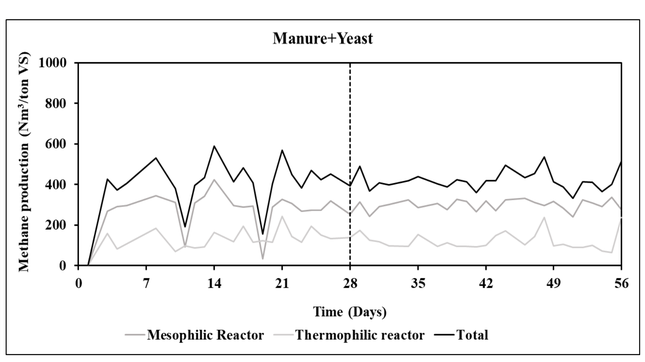
At the end of the BMP test, the following methane yields were obtained: 274 Nm^3/ton VS for manure, 294 Nm^3/ton VS for yeast concentrate, and 291 Nm^3/ton manure and yeast concentrate mixture.



The co-digestion of manure and yeast concentrate exhibited comparable methane contents in the biogas with mono-digestion of yeast concentrate but with higher H_2S content. At pilot-scale, thermophilic post-digestion boosted the methane production from 243.96 to 439.21 L/kg VS, while maintaining a high methane content between 47-61%.

Overall, acetic acid and propionic acid were the predominant volatile fatty acid species in the mesophilic and thermophilic digesters, respectively. The co-digestion experiments underscored the feasibility of using residual yeast concentrate as a co-substrate during feedstock-scare periods on the farm, leading to approximately 1.6 times higher biogas yields compared to mono-digestion. Excessive foaming and high concentrations of H_2S (up to 7600 ppm) were observed in the digesters, especially during the mesophilic co-digestion experiments. This was overcome by supplementing $FeCl_2$ to the feed to reduce the level of H_2S in the raw biogas by precipitation to FeS.





Both mono- and co-digestates from mesophilic and thermophilic digesters meet the criteria for PFC 1(A) of the Fertilising Products Regulation (EU) 2019/1009 to be potentially used as organic fertilizer, although the use of manure-derived digestates is still limited by Nitrates Directive (91/676/EEC) in Nitrate Vulnerable Zones.

Funded by the European Union

The SEMPRE-BIO project has received funding from the European Union's HORIZON-CL5-2021-D3-03-16 programme under grant agreement Nº 101084297. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.